

**PHOENIX LANDER'S THERMAL EVOLVED GAS ANALYZER: DIFFERENTIAL SCANNING CALORIMETER AND MASS SPECTROMETER DATABASE DEVELOPMENT.** B. Sutter<sup>1</sup>, H.V. Lauer<sup>2</sup>, D.C. Golden<sup>3</sup>, and D.W. Ming<sup>4</sup> and W.V. Boynton<sup>5</sup>. <sup>1</sup>Jacobs/ESCG, Houston TX, 77058, brad.sutter-2@nasa.gov. <sup>2</sup>ESCG/Barrios Tech., Houston, TX 77058. <sup>3</sup>ESCG/Hamilton Sundstrand, Houston, TX 77058. <sup>4</sup>NASA Johnson Space Center, Houston, TX 77058. <sup>5</sup>University of Arizona, Tucson, AZ 85721.

**Introduction:** The Mars Scout Phoenix lander will land in the north polar region of Mars in May, 2008. One objective of the Phoenix lander is to search for evidence of past life in the form of molecular organics that may be preserved in the subsurface soil. The Thermal Evolved Gas Analyzer (TEGA) was developed to detect these organics by coupling a simultaneous differential thermal analyzer (SDTA) with a mass spectrometer. Martian soil will be heated to ~1000°C and potential organic decomposition products such as CO<sub>2</sub>, CH<sub>4</sub> etc. will be examined for with the MS. TEGA's SDTA will also assess the presence of endothermic and exothermic reactions that are characteristic of soil organics and minerals as the soil is heated. The MS in addition to detecting organic decomposition products, will also assess the levels of soil inorganic volatiles such as H<sub>2</sub>O, SO<sub>2</sub>, and CO<sub>2</sub>. Organic detection has a high priority for this mission; however, TEGA has the ability to provide valuable insight into the mineralogical composition of the soil. The overall goal of this work is to develop a TEGA database of minerals that will serve as a reference for the interpretation of Phoenix-TEGA.

Previous databases for the ill-fated Mars Polar Lander (MPL)-TEGA instrument only went to 725°C. Furthermore, the MPL-TEGA could only detect CO<sub>2</sub> and H<sub>2</sub>O while the Phoenix-TEGA MS can examine up to 144 atomic mass units. The higher temperature Phoenix-TEGA SDTA coupled with the more capable MS indicates that a higher temperature database is required for TEGA interpretation. The overall goal of this work is to develop a differential scanning calorimeter (DSC) database of minerals along with corresponding MS data of evolved gases that can be used to interpret TEGA data during and after mission operations. While SDTA and DSC measurement techniques are slightly different (SDTA does not use a reference pan), the results are fundamentally similar and thus DSC is a useful technique in providing comparative data for the TEGA database. The objectives of this work is to conduct DSC and MS analysis up to 1000°C of select minerals that may be found in the martian soil.

**Materials and Methods:** Differential scanning calorimetry was performed with a Setaram Ligne 96 connected to a Pfeiffer ThermoStar GSD301T mass spectrometer. 20 to 30 mg samples were heated from 30 to 1100°C at heating rate of 20°C min<sup>-1</sup> at pressure

of 1000 mbar. All analysis were purged with research grade N<sub>2</sub> at a rate of 20 sccm. Result presented here will examine the DSC analysis of candidate martian minerals: calcite, gypsum, goethite, hydroxyapatite, kaolinite, and jarosite.

**Results and Discussion:** Calcite was characterized by an endotherm at 825°C that corresponded to CO<sub>2</sub> that was attributed to the breakdown of calcite and the formation of CaO (Fig. 1). Endothermic and exothermic peaks are indicated in figures by "endo" and "exo," respectively. Gypsum possessed a double peak endotherm with an onset temperature at 145°C that corresponded with structural water release to form anhydrite (Fig. 2). Two exothermic peaks associated with lattice modification occur at 415°C and 700°C. Gypsum did not evolve any gaseous sulfur species up to 1000°C. Hydroxyapatite (HA) possessed a significant endotherm near 500°C with much smaller endotherms near 100 and 173°C. Water begins to be released near 173 and this likely corresponds to dehydroxylation of HA. Low levels of CO<sub>2</sub> suggest some incorporated carbonate decomposed in the HA structure.

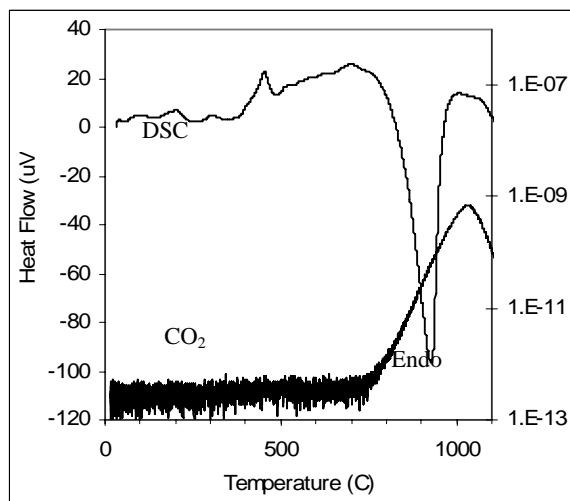


Fig. 1. Calcite DSC (left axis) and evolved CO<sub>2</sub> analysis (right axis, amps).

Kaolinite was characterized by an endotherm at 535°C and associated water release attributed to dehydroxylation of kaolinite (Fig. 3). A distinctive exotherm

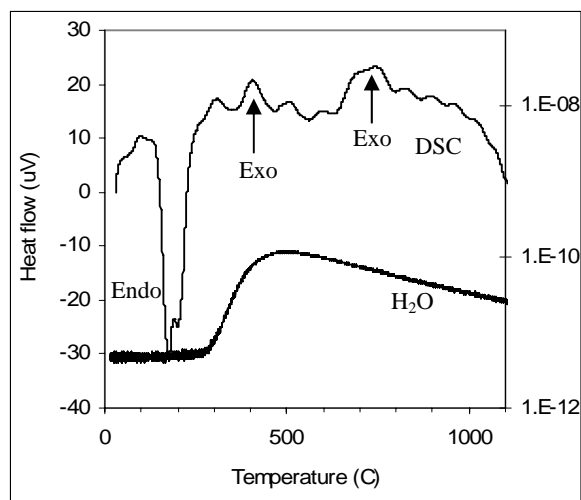


Fig. 2. Gypsum DSC (left axis) and evolved  $H_2O$  analysis (right axis, amps).

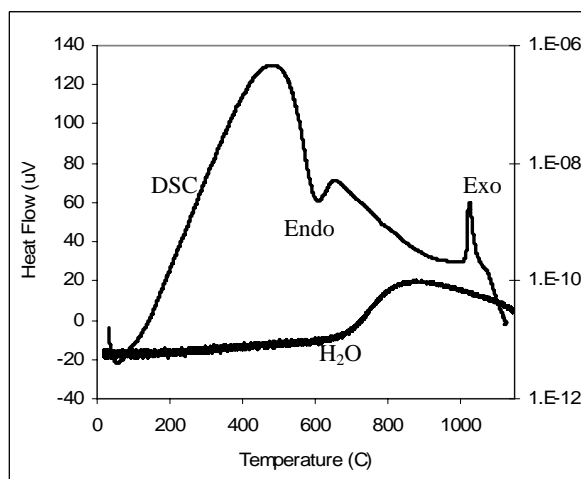


Fig. 3 Kaolinite DSC (left axis) and evolved  $H_2O$  analysis (right axis, amps).

at 1015°C is due to a crystalline transition to  $\gamma$ - $Al_2O_3$ . Goethite has doublet endotherm at 282 and 324°C due to dehydroxylation as indicated by corresponding water release. K-jarosite's endotherm at 275°C with a larger endotherm at 425°C is associated with water release indicating dehydroxylation of jarosite. The 660°C endotherm corresponds to a  $SO_2$  release indicating a loss of S from the jarosite structure.

Results clearly demonstrate that volatile bearing minerals have the potential to be identified by characteristic DSC curves and temperature dependent volatile release[1,2]. This work is laying the ground work for future work where DSC and evolved gas data will be collected at lower pressures.

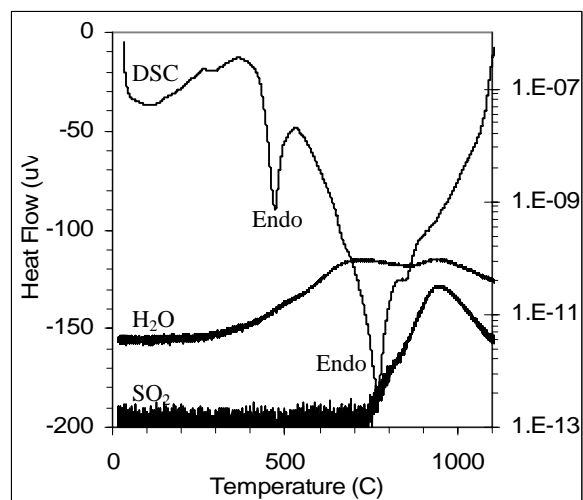


Fig. 4. Jarosite DSC (left axis), water and  $SO_2$  evolved gas analysis (amps) data (right axes).

Past work [1] has demonstrated that lower pressures affect endothermic and exothermic temperatures and corresponding temperature of volatile release relative to pressures conducted at higher pressures.

#### References::

- [1] Kauffman and Dilling (1950) *Econ. Geo.* 45, 222-244.
- [2] Kotra et al. (1982) *Icarus*, 51, 593-605.
- [3] Lauer et al. (2000) *LPSC XXXI*, Abstract #1990.